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ROOT DEVELOPMENT OF COTTON PLANTS IN THE SAN JOAQUIN VALLEY OF CALIFORNIA

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INTRODUCTION

The roots of cotton seedlings develop more rapidly and penetrate to much greater depths than is generally known. Under favorable conditions in the San Joaquin Valley of California, cotton roots were found to penetrate to depths of 3 to 5 feet by the time the seedlings were 8 to 10 inches in height. This rapid penetration of the roots allows the young seedlings to draw upon the water supply of the deeper soil and lessens the need of supplying more water in the early stages of growth.

Early irrigation of cotton is a common practice in the San Joaquin Valley largely because the habits of growth and development of the cotton plant, especially of the seedling roots, are not understood. The studies reported in this circular were conducted at the United States Cotton Field Station, Shafter, Calif., in 1929 and 1930. The soil at this station is classified as Delano sandy loam, and the plant development is representative of the normal behavior of cotton plants under general field conditions in the San Joaquin Valley.

ROOT DEVELOPMENT OF COTTON SEEDLINGS IN 1929

The investigations of root penetration in 1929 were conducted in a date-of-planting experiment. This afforded an opportunity for the study of seedlings from neighboring plots that were planted on five different dates—April 30, May 10, 20, 31, and June 10. Each of these plots was irrigated a few days before planting, and no subsequent irrigations were given until after the comparisons of root development were made. This treatment produced a normal plant development.

In studying the growth of the roots, a trench was dug on June 18 alongside a row of plants in each plot, and the taproots of several plants were traced down to the ends. Representative plants with taproots entire were taken from each of the successive plantings for comparison. Figure 1 shows, from left to right, one seedling from each

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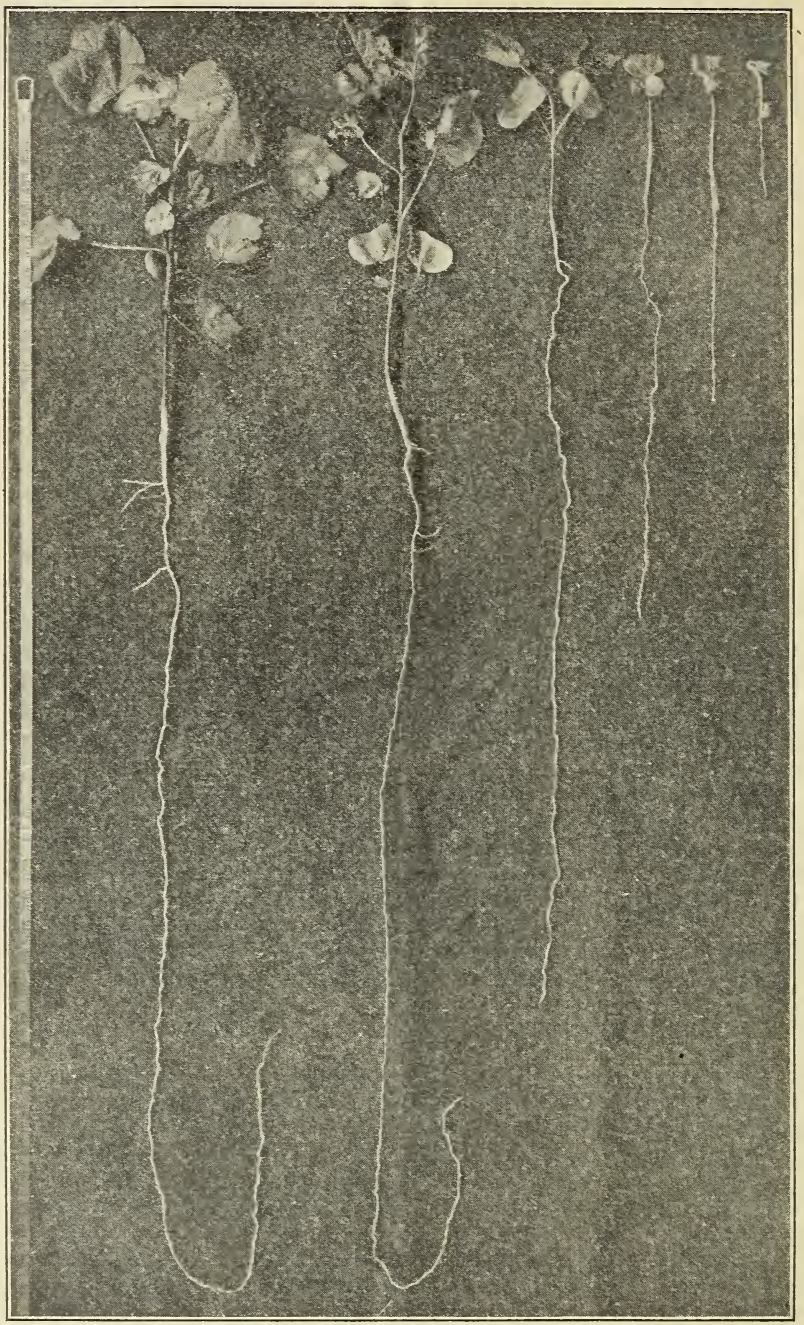

FIGURE 1.—Cotton seedlings showing (from left to right) root development at the following days after planting: 49, 39, 29, 18, 8, and 8

of the successive plantings except the last, of which two plants are shown. These two plants are from seed planted at the same time, but one did not germinate promptly and the seedling had not reached the surface of the ground. The bend in the roots of the two plants at the left was made when photographing, in order to reduce the size of the illustration, and does not represent the natural position.

The records of the seedlings shown in Figure 1 are presented in Table 1, which shows the date of planting, the date of observation, the number of days between planting and observation, the height of the plants, the number of true leaves, and the depth to which the taproots had penetrated.

TABLE 1.—*Root development of cotton seedlings in date-of-planting experiment at the United States Cotton Field Station, Shafter, Calif., 1929*

Date of planting	Interval between planting and observation (days)[1]	Height of plants (inches)	Number of leaves	Depth of taproot penetration (inches)
Apr. 30	49	9½	8	38
May 10	39	10	7	34
May 20	29	5½	3	24
May 31	18	Cotyledon stage	0	13
June 10	8	Just up	0	7¼

[1] Plants were observed June 18.

Additional observations of cotton root development were made July 3 in a plot of cotton that could be reached with a garden hose from the domestic water supply. This plot was planted May 2 and received no subsequent irrigation. A trench about 6 feet deep was dug alongside a row of plants in this plot, and the plants were removed by washing away the soil. In this way it was possible to obtain plants with many of the lateral roots attached. Very few roots were observed in digging the trench, but after a little of the soil had been washed away numerous fine lateral roots were visible, as shown in Figure 2. These roots radiated from the taproot to a depth of about 3 feet, becoming shorter and finer as a greater depth was reached. Several plants were removed with taproots entire and with many laterals. Figure 3 shows three representative plants of which the middle plant was 8 inches in height and had nine true leaves and five fruiting branches; its taproot was traced to a depth of 4 feet 10 inches from the surface of the ground and measured 5 feet in length.

The seedlings in this plot had begun to show signs of water stress on July 3, when the first observations were made; but no irrigations were given throughout the season, and the plants developed very slowly and became badly stunted owing to lack of water. Plants removed July 31 were little larger than those removed July 3, but many of them had developed flowers. Several plants were removed July 31, but only one with the taproot entire. This plant was 8 inches tall, and the taproot was 6 feet 9 inches long.

ROOT DEVELOPMENT OF COTTON SEEDLINGS IN 1930

Additional data on the penetration of cotton-seedling roots were obtained in 1930. A plot in which the soil was fairly uniform to a depth of 7 to 8 feet was selected for normal-penetration studies.

This plot was irrigated April 21 and planted May 9. No subsequent irrigations were given until after these studies of root development were completed. The plants developed normally and showed no need for irrigation until the last few days before the final observations

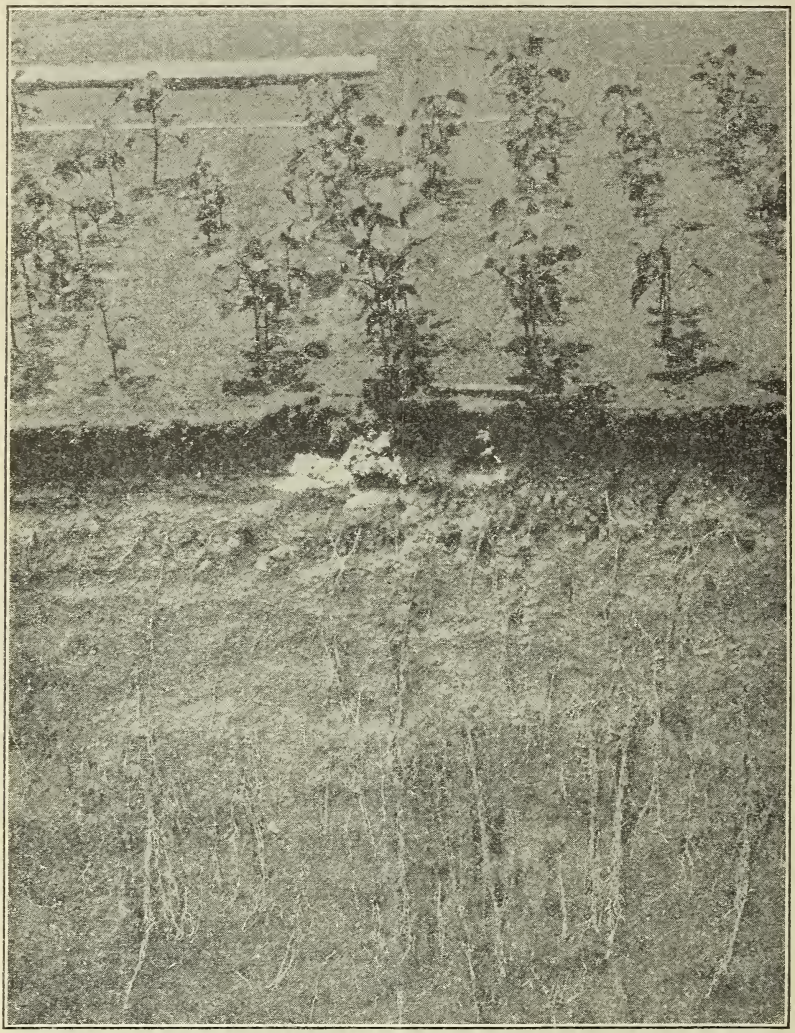

FIGURE 2.—Lateral roots of cotton seedlings exposed on the wall of the trench after the soil had been washed away

of root development were made. At that time the indications of water stress were very slight, and the plants were just reaching the optimum condition for receiving the first irrigation after planting. Plants were removed from this plot for study on June 16 and 27, and on July 7 and 16. In each case a representative section of a row was selected, and several consecutive plants were removed with taproots entire.

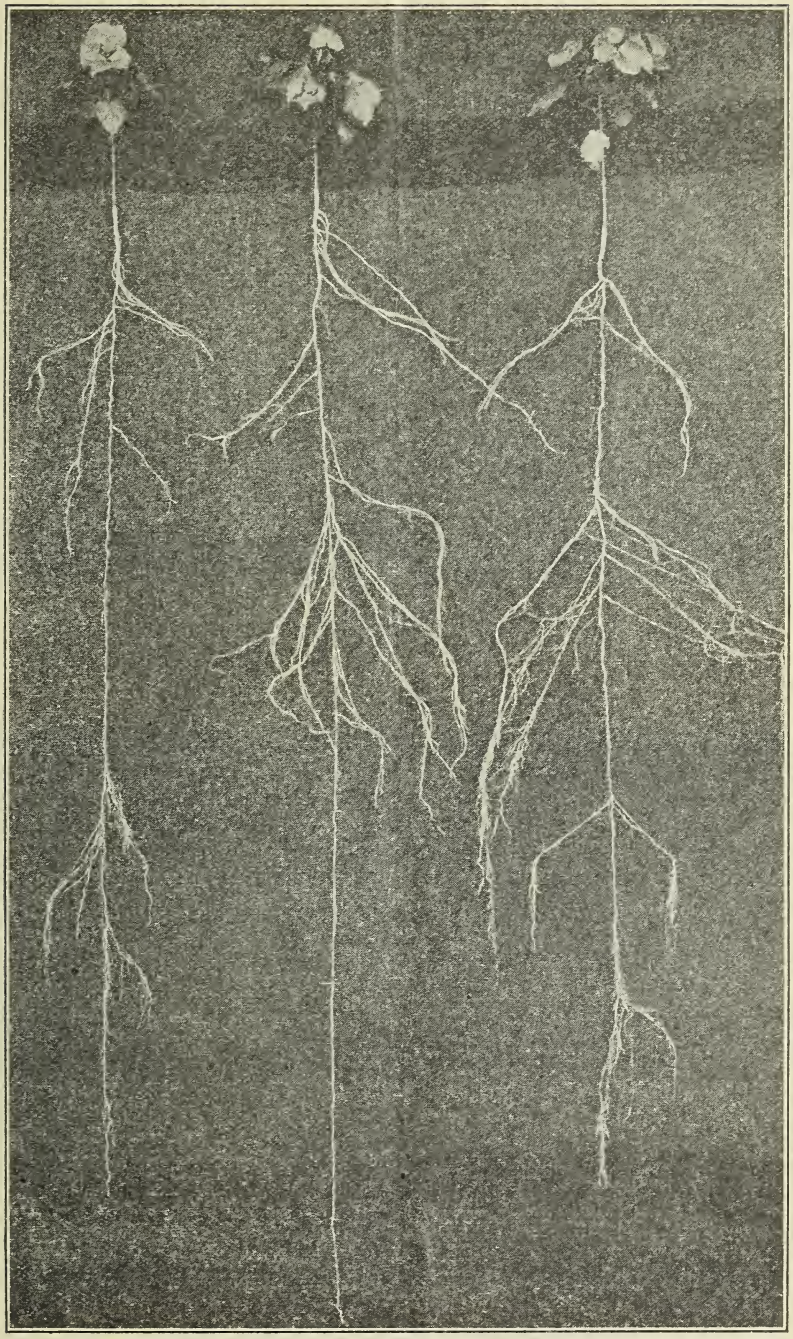

FIGURE 3.—Cotton seedling roots removed by carefully washing away the soil. Some of the laterals are shown, but many others were broken off in washing

The average depth of taproot penetration of plants removed June 16 and 27 was more than 6 times the average height of the plants, and individual plants removed on these dates had taproots that had penetrated to depths more than 8 times their height. The average depth of taproot penetration for plants removed July 7 was 4.5 times the average height of the plant, and for plants removed July 16 it was 5.1 times the average height. Records showing the height of plant, number of true leaves, and the depth of taproot penetration for each plant removed are presented in Table 2.

TABLE 2.—*Root development of cotton seedlings planted May 9, 1930, at the United States Cotton Field Station, Shafter, Calif.*

Date of observation	Plant No.	Height of plants	True leaves	Depth of taproot penetration	Date of observation	Plant No.	Height of plants	True leaves	Depth of taproot penetration
		Inches	*Number*	*Inches*			*Inches*	*Number*	*Inches*
June 16	1	6	7	43	July 7	1	15	12	85
	2	6	8	49		2	14	12	52
	3	7	7	45		3	16	12	67
	4	8	7	40		4	15	13	68
	5	6	6	25		5	14	11	60
	6	7	9	43	July 16	1	13	12	72
June 27	1	9	9	53		2	17	15	86
	2	8	8	58		3	17	14	93
	3	11	10	62		4	12	12	74
	4	7	8	57		5	18	16	64
	5	8	9	53					
	6	8	9	51					

EFFECTS OF EARLY IRRIGATION

Further observations were made in 1930 to study the effects of different irrigation treatments. Plants removed from adjoining plots that had received contrasting irrigation treatments showed striking differences in lateral root development. In plots that had been irrigated early in the season before the plants showed signs of a moisture deficiency, numerous large lateral roots were found radiating from the upper portion of the taproots, while in the plots that had received no irrigation after planting, very few or no lateral roots had developed from the upper portion of the taproots. (Fig. 4.)

The penetration of the taproots was rather inconsistent under each irrigation treatment and appeared to be greatly affected by soil variations. Streaks of coarse sand occurred at various depths in all the plots that were used in the irrigation studies, and in many instances the taproots would penetrate only a few inches into the sand. The tips of such roots perished and rotted away, as shown in Figure 5. Thus it was not possible to gather accurate data regarding the effects of the early or the deferred irrigation treatment upon the taproot penetration.

The root development of cotton seedlings, as shown in these records, involves a much deeper penetration of the soil than is generally known. This information should help the grower to a better understanding of the handling of the crop. Many growers irrigate early in the season if it appears that the seedlings are not making rapid growth, in the belief that the soil moisture may have "gone down" below the seedling roots. Some of the growers pull up cotton seedlings to see if the

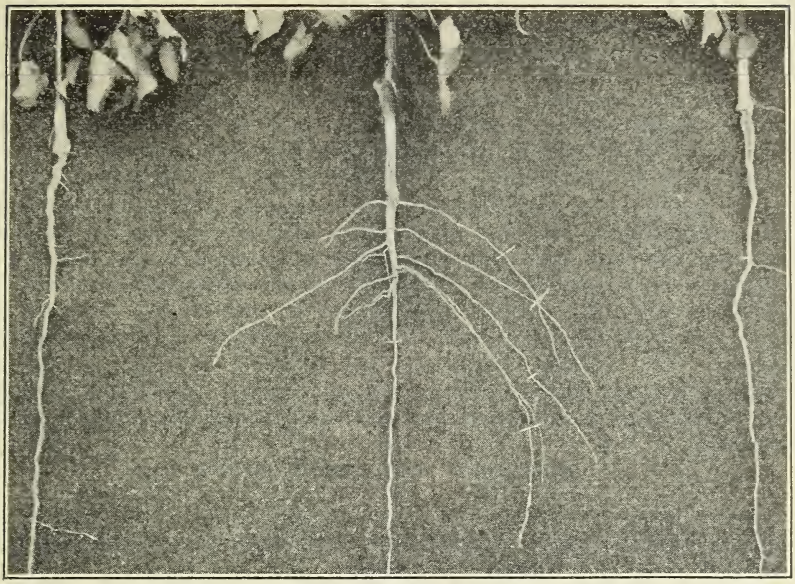

FIGURE 4.—Upper portions of cotton roots showing effect of early irrigation upon the development of lateral roots near the surface. The center plant is from a plot irrigated early in the season and the others are from an adjoining plot that had not been irrigated after planting

FIGURE 5.—Taproots ending in coarse sand perished, as shown at right, as contrasted with normal taproots ending in good soil, as shown at left. Natural size

roots are "down to moisture," but in such cases a mistaken impression is likely to be formed, since the taproot usually breaks off near the surface of the ground. Thus it may appear that irrigation is needed, when in reality the roots may be down several feet and in contact with ample moisture.

In the San Joaquin Valley the failure of cotton seedlings to grow rapidly in the spring is seldom due to lack of moisture in the soil. Cool weather is usually responsible for the slow growth of young plants early in the season, and no advantage is to be gained by irrigation under such conditions. A pronounced wilting of the leaves may occur during the first warm days after a cold period, notwithstanding the fact that ample moisture is present in the soil. Such wilting is explained by the fact that the low temperature of the soil interferes with the supply of moisture to the leaves, to meet the increased need resulting from the warm-weather conditions aboveground. The wilting symptoms are relieved as soon as the soil becomes warmer, and no serious damage results. Adding more water may delay the warming of the soil and retard the growth of the seedlings.

SUMMARY AND CONCLUSIONS

Observations of cotton root development made under field conditions at Shafter, Calif., in 1929 and 1930 show that cotton seedlings establish deep root systems promptly. For this reason it is seldom necessary to irrigate until a long period after planting.

Plants 8 to 10 inches in height and with 8 to 10 true leaves were found to have taproots extending 50 to 60 inches below the surface of the ground. Even the small seedlings in the cotyledon stage, with no true leaves, had roots down 12 to 16 inches.

It was observed that streaks of coarse sand wherever encountered interfered with the penetration of roots. In many cases the roots ended abruptly after penetrating only a few inches into the sand, the tips having perished.

Many large lateral roots developed near the surface of the ground on plants that were irrigated early in the season, while in contrast very few or no lateral roots developed near the surface on plants that had not been irrigated.

The deep penetration of roots in the early stages of growth undoubtedly is desirable, since it affords a more constant condition for plant development. The plants are not forced into too rank growth in periods of warm weather and are less susceptible to being checked by the drying of the surface soil.

Although the work reported in this publication was done in the San Joaquin Valley, the information regarding the deep penetration of the roots in early stages of growth is a fact of practical importance to cotton growers in all of the irrigation districts of the Southwestern States, including Texas, New Mexico, Arizona, and California, and is of general interest to all cotton growers and experimenters.

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